ARTICLE IN PRESS

Transportation Research Part D xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Transportation Research Part D

journal homepage: www.elsevier.com/locate/trd

Greening ports and maritime logistics: A review

Hoda Davarzani [a], Behnam Fahimnia [b,*], Michael Bell [b], Joseph Sarkis [c]

[a] Discipline of Business Analytics, The University of Sydney Business School, The University of Sydney, Australia
[b] Institute of Transport and Logistics Studies (ITLS), The University of Sydney Business School, The University of Sydney, Australia
[c] Foisie School of Business, Worcester Polytechnic Institute, MA 01609-2280, USA

ARTICLE INFO

Article history:
Received 11 March 2015
Revised 17 June 2015
Accepted 11 July 2015
Available online xxxx

Keywords:
Green
Port
Maritime logistics
Environmental sustainability
Literature review
Bibliometric analysis

ABSTRACT

This paper aims to examine the past and present research on 'green ports and maritime logistics' in order to identify established research streams and fertile research areas with potential for future investigations. Using rigorous bibliometric and network analysis tools, the paper completes a systemic mapping of the existing literature and identifies the key investigators, collaboration patterns, research clusters and interrelationships, and the "seminal research areas" that have provided the field with the foundational knowledge, concepts, theories, tools, and techniques. Major articles within each seminal research area are also identified. This will allow new researchers to quickly build understanding in a particular sub-field by reading these major articles. The findings obtained from the evolution of seminal research areas over time are important from both research and practice perspectives and can help the field grow in many dimensions.

Introduction

The emissions of port operations and shipping have long remained out of sight and out of mind, until recently. Disasters leading to oil spillages, culminating in the Exxon Valdez accident in Alaskan waters, prompted the MARPOL (Marine Pollution) convention and the phasing out of single-hulled oil tankers. This maritime based environmental disaster led to the Valdez Principles which then evolved to the CERES principles (Coalition for Environmentally Responsible Economies) and eventually the standard in corporate sustainability reporting from the global reporting initiative (Waddock and White, 2007). Thus, from a historical perspective maritime and port shipping emissions has had significant influence on corporate greening and environmental sustainability. Yet, it is only recently that emissions from ships and port equipment have been perceived as a problem and corresponding research has occurred.

Not only is there significance and focus on reducing emissions and reactive greening approaches for maritime and port logistics, but growth in a more proactive focus. This proactive focus includes topics and issues related to the greening of transportation and logistics across supply chains (Fahimnia et al., 2015a,b). For example, it has become evident that organizations need to strategically address various actors pressures to green their processes and products, especially the greening of their global logistics and transportation networks (Fahimnia et al., 2015c; Song and Parola, 2015). This extended focus requires the explicit consideration and management of port and maritime logistics within supply chains.

The concerns include technical, operational, and economic dimensions. For example, regulatory actors have caused concern about the impact of burning high sulfur fuel at sea on adjacent populated areas is leading to the introduction of

* Corresponding author at: Rm 215, 378 Abercrombie Street (Building H73), Darlington, NSW 2008, Australia. Tel.: +61 2 9114 1801; fax: +61 2 9114 1863.
E-mail addresses: hoda.davarzani@sydney.edu.au (H. Davarzani), behnam.fahimnia@sydney.edu.au (B. Fahimnia), michael.bell@sydney.edu.au (M. Bell), jsarkis@wpi.edu (J. Sarkis).

http://dx.doi.org/10.1016/j.trd.2015.07.007
1361-9209/

Emission Control Areas (ECAs), starting with the coasts of North America, the Baltic Sea and the English Channel. In these areas, ships are required to switch to low sulfur fuel (currently no more than 0.1% sulfur by weight rather than 3.5% outside ECAs, according to Regulation 14 of the IMO[1]). Other measures include slow steaming in the vicinity of coasts and ports, the use of scrubbers and switching to cleaner fuels like diesel or liquefied natural gas (Zis et al., 2014).

More proactively, and competitively, in the context of ship construction and technology, some ships are more environmentally friendly than others by design, as measured by the Energy Efficiency Design Index (EEDI). Newer ships tend to be more energy efficient than older ones as hull and engine designs improve with time, and engines lose efficiency with age and use. Some ports have considered including the EEDI in the determination of port fees, to encourage more energy efficient shipping. Shipping lines now commonly optimize routes with respect to weather and currents to save fuel. Likewise ballast and trim can be optimized to save fuel.[2]

Operationally, in ports, there has been a move to encourage ships to turn off their engines and generators while at berth and connect to a landside electricity supply, a process referred to as 'cold ironing' (Zis et al., 2014). Landside electricity may also be used to power cranes and equipment for moving containers, perhaps accompanied by automation. The electrification of cranes opens up the possibility of introducing regenerative technology, enabling electricity to be generated when containers are lowered and reducing crane energy consumption by around 30%[3]. Research is ongoing on the use of batteries to power vehicles for moving containers horizontally in ports. In general, the impact of electrification on emissions and the environment will depend on how and where the electricity is generated. Ports are frequently in windy locations with space available, opening up the possibility of generating electricity in environmentally friendly ways on site by installing wind turbines or importing and burning biomass. Thus, a spectrum of practical organizational and supply chain issues arise for the port and maritime transportation greening.

A number of reviews have been completed on specific aspects of ports and maritime logistics such as risk assessment and analysis (Goerlandt and Montewka, 2015; Soares and Teixeira, 2001), fleet composition and routing (Hoff et al., 2010), and ship routing and scheduling (Christiansen et al., 2013). The more recent reviews with some sustainability focus have been more problem-specific, such as the use of multi-objective decision methods in sustainable maritime transport (Mansouri et al., 2015) or bunker consumption optimization methods (Christiansen et al., 2013). To the best of our knowledge, a comprehensive review on the literature of green ports and maritime logistics is none-existent. Given the recent developments in ports and shipping aimed at reducing emissions and improving energy efficiency, it is timely to look at how the corresponding academic research field is evolving. Using rigorous bibliometric and network analysis tools, this paper reviews the literature of green ports and maritime logistics to (1) provide some initial statistics of the key journals, authors and institutions that have contributed to the field, (2) identify research areas that are well-researched and the streams that have better potentials for making new contributions (literature classification and data clustering), and (3) identify the studies and research areas that have provided the field with foundational knowledge and base tools/techniques (we named this 'seminal research clusters').

The remainder of this paper is organized as follows. The 'research methodology' section discusses the data collection and analysis methods along with some initial statistics regarding recent publication trends in the area of green ports and maritime logistics. Next section presents the initial bibliometric analysis resulting in additional author and affiliation statistics. Next, a through network analysis is presented that identifies and evaluates the key clusters of primary research streams and seminal research areas. We conclude this paper with a discussion on research limitations and potential research directions.

Research methodology

Literature reviews aim to map and evaluate the body of literature and identify potential research gaps highlighting the boundaries of knowledge (Tranfield et al., 2003). Structured literature reviews are completed through an iterative cycle of defining appropriate search keywords, searching the literature and completing the analysis (Saunders et al., 2009). Rowley and Slack (2004) recommend a structured methodology for scanning resources, designing the mind map to structure the literature review, writing the study and building the bibliography. Seuring and Gold (2012) present content analysis as an effective tool for conducting a systematic and transparent literature review through four steps of material collection, descriptive analysis, category selection and material evaluation. Inspired by the work of Rowley and Slack (2004) and Seuring and Gold (2012), we use a four-step methodology for data collection and comprehensive evaluation of the field aiming to identify the most influential studies, determine the topical areas of current research interest and provide insights for current research interests and directions for future research in the field.

Defining the appropriate search terms

Identifying the appropriate search terms and keyword structure was completed through several trial and error attempts. We used the following iterative multi-step process to design an effective keyword structure:

[1] http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Sulphur-oxides-%28SOx%29-%E2%80%93-Regulation-14.aspx, accessed 20 January 2015.

[2] Second IMO study on GHG emissions, www.imo.org/blast/blastDataHelper.asp?data_id=27795, accessed 20 January 2015.

[3] "FUEL FOR THOUGHT: Identifying potential energy savings in the Australian road and rail sectors", Australian Government, 2012.

Please cite this article in press as: Davarzani, H., et al. Greening ports and maritime logistics: A review. Transport. Res. Part D (2015), http://dx.doi.org/10.1016/j.trd.2015.07.007